Single-Phase BLDC Fan Driver IC

General Description

The RT8725 is a single-phase driver IC for fan motors. Rotation speed is controlled by PWM input signal. The RT8725 provides several protection features including standby mode, thermal shutdown, lock protection, over-current protection and under-voltage protection. The Built-in smart force start-up function overcomes and avoids wrong status when electrical noise occurs during start-up. In the standby and thermal shutdown mode, the supply current is less than 100µA. The rotation frequency is generated by FG output.

Ordering Information

RT8725 □□

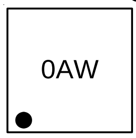
- Package Type
  QU : UDFN-8L 2x3 (U-Type)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Marking Information



0A : Product Code

W : Date Code

Features

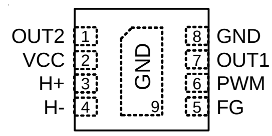
- **Low Supply Current**
- **Smart Force Start-up Function**
- **PWM Supply Voltage Control Fan Speed**
- **Built-in Motor Lock Protection and Automatic Restart**
- **Built-in Thermal Shutdown**
- **Built-in Over-Current Protection**
- **Built-in Frequency Generator with FG Output Signal**
- **RoHS Compliant and Halogen Free**

Applications

- Single Phase Fan Motor for Notebook or PC

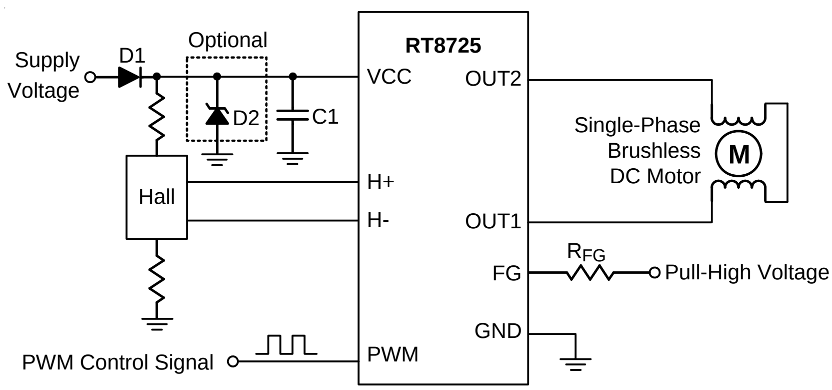
Pin Configurations

(TOP VIEW)



UDFN-8L 2x3

Simplified Application Circuit



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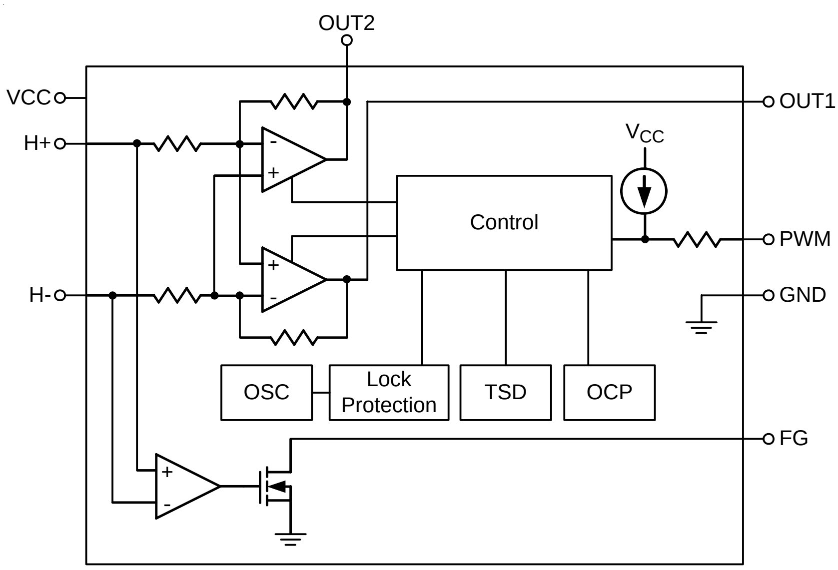
Function Pin Description

Pin No.	Pin Name	Pin Function
1	OUT2	H-Bridge Output for DC Motor.
2	VCC	Supply Voltage Input.
3	H+	Positive Hall Input.
4	H–	Negative Hall Input.
5	FG	Frequency Generator Output for Rotation Speed. This is an open-drain output.
6	PWM	PWM Signal Input.
7	OUT1	H-Bridge Output for DC Motor.
8, 9 (Exposed Pad)	GND	Power Ground. The Exposed Pad should be soldered to a large PCB and connected to GND for maximum thermal dissipation.

Function Block Diagram



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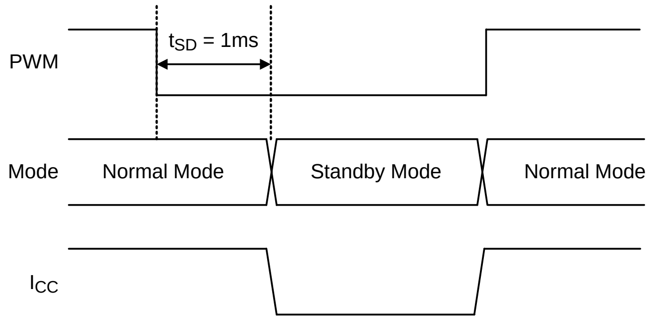
Operation

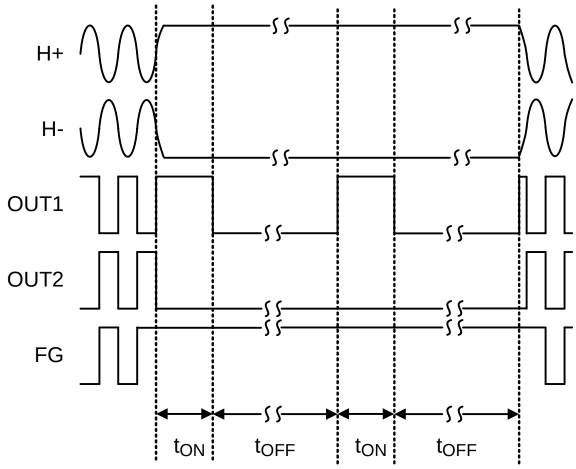
Operation Mode

The operation mode of the RT8725 is determined by the external PWM input. During power up, if the PWM input stays at a low-level voltage, the IC will enter low-power standby mode. If the PWM input is kept at a high-level voltage or with a periodic pulse signal, the IC will operate in normal mode. On the other hand, during normal mode operation, when the PWM input is set to a low-level voltage for more than 1ms (typ.), the IC will enter low-power standby mode. In the standby mode, the supply current can be reduced to 100μA. Once the PWM input is pulled high again, the IC will be activated immediately for normal operation.



Motor Lock Protection and Automatic Restart

When the motor is locked, the RT8725 will try to re-start the motor within 0.5 seconds typically (t_{ON}). If the motor fails to re-start, the driver will disable the output regardless of the PWM duty ratio to prevent the motor coil from burnout. After the lock off-time of 5 seconds in typical (t_{OFF}), the driver will try to restart the motor again. If the motor is still locked, then the iteration of the lock detection and restart will be repeated until the lock condition is released or the PWM input is pulled low.



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Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, VCC (<300ns) ---------- –0.3V to 10V
- Hall Input Voltage Range, H+, H– ---------- –0.3V to 6V
- PWM Input Voltage, PWM ---------- –0.3V to 6V
- Output Voltage, OUT1, OUT2, FG ---------- –0.3V to 6V
- Maximum Output Current, OUT1, OUT2 ---------- 1A
- Power Dissipation, P_D @ T_A = 25°C, θ_{JA} = 150°C

  UDFN-8L 2x3 (One-Layer) ---------- 0.5W

  UDFN-8L 2x3 (Two-Layer) ---------- 2.49W
- Package Thermal Resistance (Note 2)

  UDFN-8L 2x3 (One-Layer), θ_{JA} ---------- 245.8°C/W

  UDFN-8L 2x3 (One-Layer), θ_{JC} ---------- 8.3°C/W

  UDFN-8L 2x3 (Two-Layer), θ_{JA} ---------- 50.2°C/W

  UDFN-8L 2x3 (Two-Layer), θ_{JC} ---------- 8.3°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VCC ---------- 1.8V to 5.5V
- Hall Input Voltage, H+, H– ---------- 0.4V to (V_{CC} – 1.1V)
- PWM Input Voltage, PWM ---------- 0V to V_{CC}
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 105°C

Electrical Characteristics

(V_{CC} = 5V, T_A = 25°C, Unless Otherwise specification)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Current		I_{CC1}	Rotation Mode and Lock Protection Mode	--	3.5	5	mA
Standby Current		I_{CC2}	Standby Mode (PWM = 0)	--	100	200	μA
PWM Input Voltage	High-Level	V_{PWM_H}		1.8	--	V_{CC} + 0.5	V
	Low-Level	V_{PWM_L}		0	--	0.7	
PWM Input Frequency		F_{PWM}		2	--	50	kHz
PWM Input Leakage	High-Level	I_{PWM_H}		--	0	5	μA
	Low-Level	I_{PWM_L}		–30	–10	0	
Supply Voltage Threshold		V_{CC_TH}		3	3.5	4	V
Input-Output Gain		G_{IO}	V_{OUT} / H+ – H-	42	44.6	47	dB
Output Voltage		V_O	I_O = 250mA	--	0.2	0.4	V

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Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
FG Low Voltage	V_{FG}	I_{FG} = 5mA	--	0.1	0.2	V
FG Leak Current	I_{FG}	V_{FG} = 5V	--	--	1	μA
Input Offset Voltage	V_{HOFS}		--	--	±6	mV
Input Hysteresis Voltage	V_{Hys}		±5	±10	±15	mV
Lock Detection On-Time	t_{ON}		0.35	0.5	0.65	s
Lock Detection Off-Time	t_{OFF}		3.5	5	6.5	s
Thermal Shutdown Threshold			--	160	--	°C
Thermal Shutdown Hysteresis			--	30	--	°C
Quick Start						
Standby Detection Time	t_{SD}		0.7	1	1.3	ms
Quick Start Enable Time	t_{QS}		--	30	--	μs

Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity one/two-layer test board per JEDEC 51-3. θ_{JC} is measured at the exposed pad of the package.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

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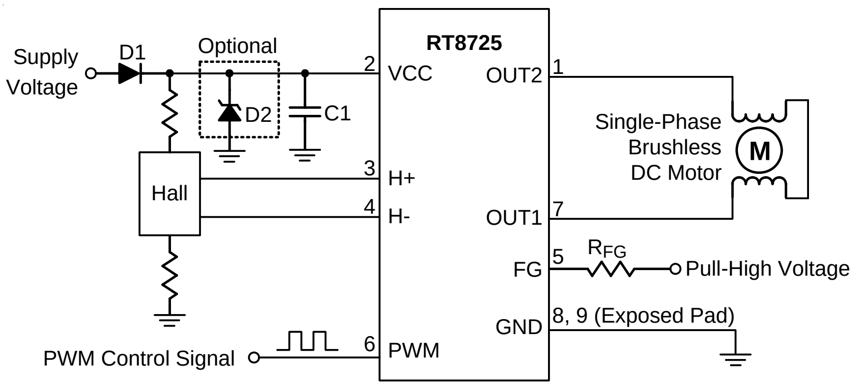
Typical Application Circuit



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Application Information

Quick Start Function

If the PWM is pulled low for a delay time, t_{SD}, the RT8725 will enter standby mode. Once a PWM signal is detected, the RT8725 will provide outputs after a delay time, t_{QS}.

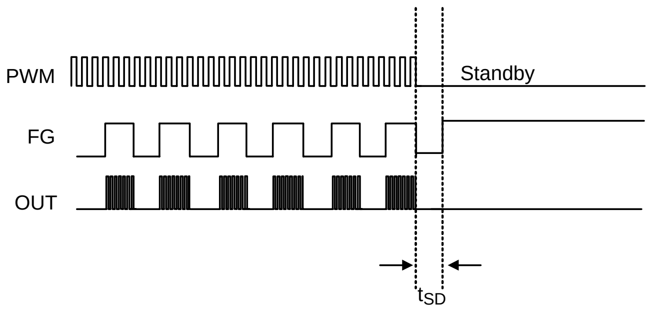

Figure 1

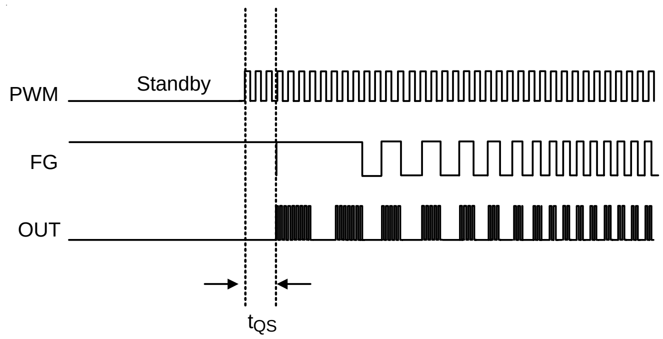

Figure 2

PWM Speed Control

The motor speed can be controlled by the external signal at PWM pin and the supply input voltage. When a PWM signal is provided to the PWM pin, the driver output will follow the duty ratio of the PWM input signal. The switching frequency of the driver is dependent on the PWM input frequency. Therefore, the motor speed is controlled by the PWM signal. The available PWM input frequency range is from 2kHz to 50kHz. When the PWM input is fixed at a high-level voltage (>1.8V) or floating, the motor will rotate with full speed. When the PWM input is fixed at a low-level voltage (<0.7V), the motor will decelerate to stop. In standby mode, the supply current can be reduced to 100μA.

Frequency Generator (FG)

The FG pin is an open drain output. A pull-up resistor (1kΩ to 10kΩ) is recommended to be connected from this pin to a high level voltage (<5.5V) for frequency generator function.

Thermal Shutdown

The RT8725 provides a thermal shutdown function to prevent overheating due to excessive power dissipation. The function function shuts down the switching operation when the junction temperature exceeds 160°C. Once the junction temperature cools down by around 30°C, the main converter will automatically resume switching. To maintain continuous operation, the junction temperature should be kept below 130°C.

Truth Table

H+	H-	PWM	OUT1	OUT2	FG	Mode
H	L	H	H	L	L (Output : ON)	Operation Mode
L	H		L	H	Z (Output : OFF)	
H	L	L	L	L	L (Output : ON)	
L	H		L	L	Z (Output : OFF)	
H	L	-	L	L	Z (Output : OFF)	Lock Mode
L	H		L	L	Z (Output : OFF)	
-	-	L	L	L	Z (Output : OFF)	Standby Mode

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Over-Current Protection

The RT8725 includes an Over-Current Protection (OCP) feature to prevent the large supply current form supply voltage to output. When the over-current occurs, the circuit will disable the output and the motor rotor will stop. After a time duration (t_{OFF}, typical 5s), the IC will automatically try to restart the motor. If the supply current is still larger, the output will be shut down immediately.

Force Start-Up Control

The motor speed is controlled by the external PMW signal. In order to successfully start the motor with lower PWM duty, a start-up mechanism is applied to check if output duty from the external PWM signal can drive the motor to rotate in a period (0.4 x t_{ON}, typ. 0.2s). If it cannot drive the motor to rotate because of its low duty, an internal PWM signal with higher duty will be adopted to drive the motor. The internal PWM duty varies according to input voltage VCC ($V_{CC} \geq 3.5V$, duty = 50%; $V_{CC} < 3.5V$, duty = 100%).

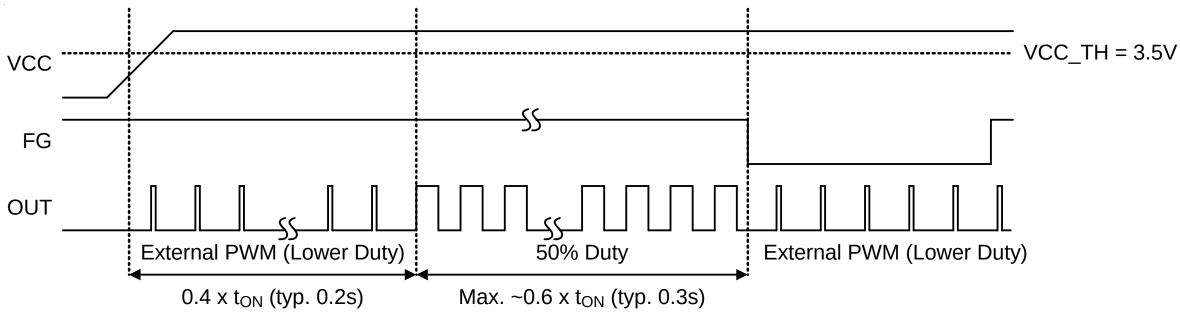

Figure 3. Forced Start-Up when VCC > VCC_TH

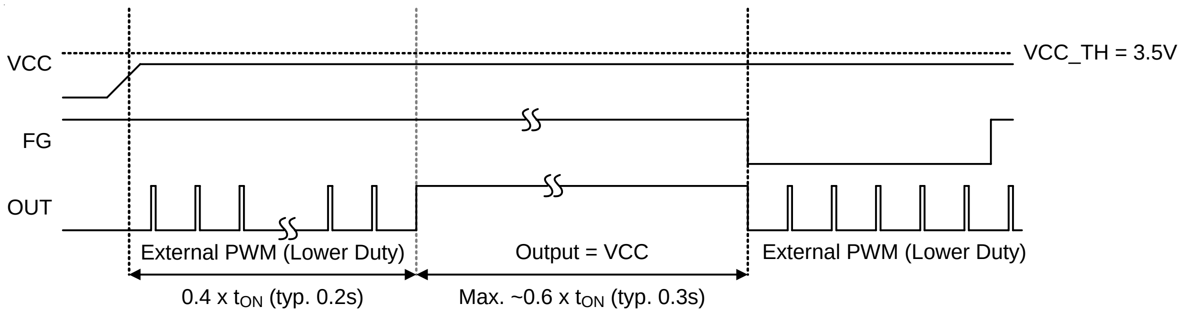

Figure 4. Forced Start-Up-1 when VCC ≤ VCC_TH

FG Output when Motor is in the Lock State

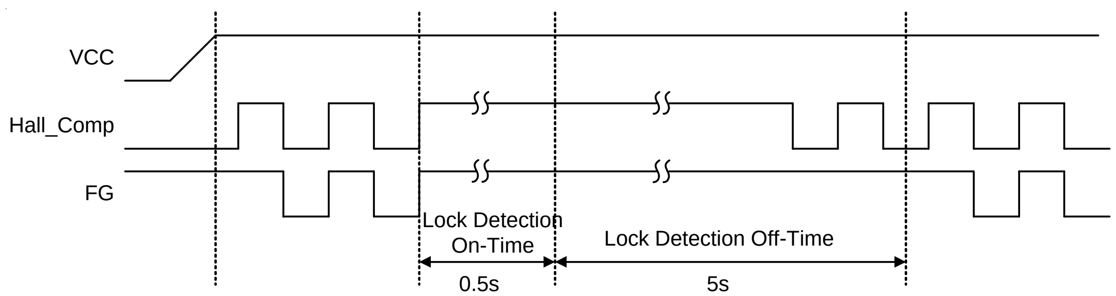

Figure 5. FG Output when Motor is in the Lock State

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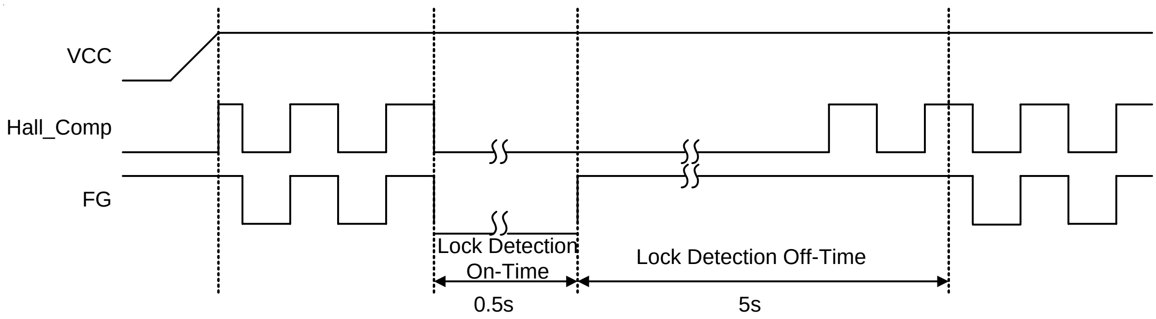

Figure 6. FG Output when Motor is in the Lock State-1

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For UDFN-8L 2x3 package, the thermal resistance, θ_{JA}, is 245.8°C/W on a standard JEDEC 51-3 one-layer thermal test board. For UDFN-8L 2x3 package, the thermal resistance, θ_{JA}, is 50.2°C/W on a standard JEDEC 51-3 two-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C − 25°C) / (245.8°C/W) = 0.4W for UDFN-8L 2x3 package (One-Layer)

$P_{D(MAX)}$ = (125°C − 25°C) / (50.2°C/W) = 1.99W for UDFN-8L 2x3 package (Two-Layer)

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 7 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

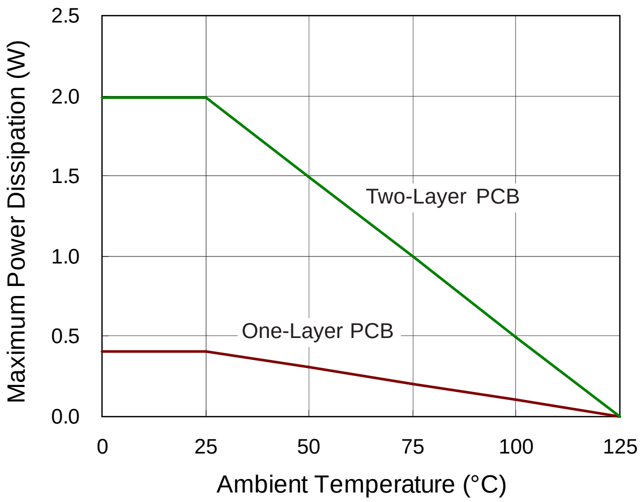

Figure 7. Derating Curve of Maximum Power Dissipation

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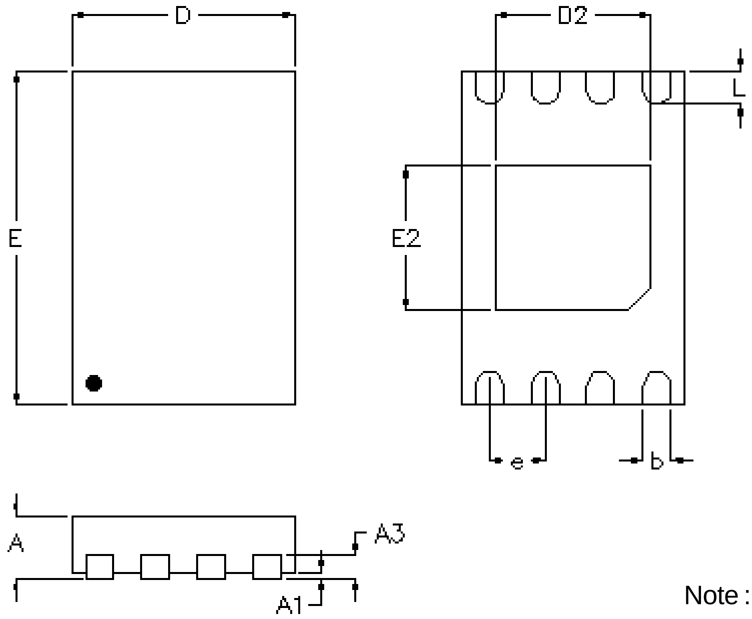
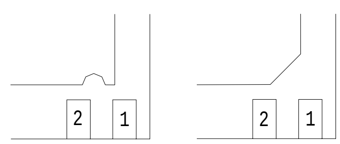
Outline Dimension





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A3	0.100	0.175	0.004	0.007
b	0.200	0.300	0.008	0.012
D	1.900	2.100	0.075	0.083
D2	1.600	1.700	0.063	0.067
E	2.900	3.100	0.114	0.122
E2	1.750	1.850	0.069	0.073
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

U-Type 8L DFN 2x3 Package

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